Step 3: **Synthesis**

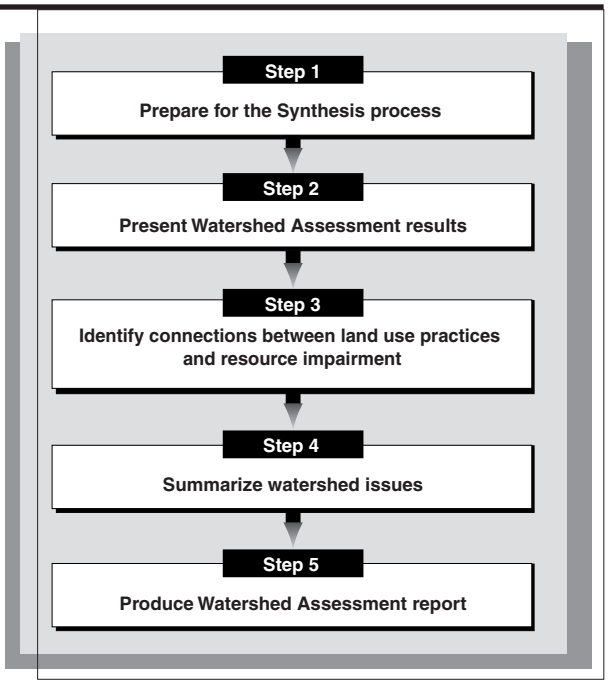
Introduction

The Synthesis step of the WAM process provides an opportunity for interaction among the assessment team members to provide a more comprehensive picture of the watershed. Synthesis is generally an interdisciplinary evaluation involving a larger assessment team, but even smaller assessment teams can summarize and evaluate the information in an interdisciplinary fashion. These discussions often lead to new insights about important watershed processes and the status of community resources.

Synthesis Process

Step Chart

Procedure



The objectives of the Synthesis step are as follows:

- To share information generated from various areas of the assessment.
- To identify important interactions among land uses, watershed processes, and community resources.
- To summarize key watershed issues to be addressed in the Management Solutions step.
- To determine potential future actions for key watershed issues (e.g., Level 2 assessment, management practices, restoration plans, monitoring plans).

Step 1. Prepare for the Synthesis process

The Synthesis process is typically organized and facilitated by the assessment team leader. The assessment team members are the primary participants, but other community members may also be interested in following the process. The team leader will need to notify potential participants and schedule Synthesis meetings. Synthesis meetings may last from two days to a few weeks, depending on the complexity of watershed issues and the scope of the assessment. If more than two to three days will be required to complete the Synthesis process, it is advisable to spread out the meetings over two to three weeks. A break between Synthesis sessions is important not only to maintain the focus of the participants but also to allow for follow-up work to address questions raised during Synthesis or to fine-tune the assessment.

At the Synthesis meetings, the assessment team members should be prepared to present the results of their respective assessments along with appropriate maps. The checklist provided in Box 1 summarizes the important products from each WAM technical module. Depending on the scope of the assessment, some of these products may not have been created. Ideally, the analysts would have a draft of their module reports completed. Writing draft reports prior to Synthesis ensures that critical work has been completed and helps identify information needs and potential linkages with other modules. Completion of maps and forms will help make the Synthesis meetings effective and efficient.

A number of general Synthesis questions that may need to be addressed by each module are presented in Box 2. These questions illustrate the types of issues addressed by the Synthesis process and may not be appropriate for all watershed assessments.

Step 2. Present Watershed Assessment results

If some Synthesis participants are unfamiliar with the WAM process, the team leader should orient participants on the purpose of the Watershed Assessment, the issues identified in Scoping that were investigated by the assessment team, and the role of Synthesis meetings in the WAM process.

Box 1. A checklist of module products needed for Synthesis

Module	Products
Community Resources	☐ Map CR1. Community resources
	☐ Form CR1. Categorization of community resources
	☐ Form CR2. Trends in community resource conditions
Aquatic Life	☐ Map AL1. Aquatic species distribution
	☐ Map AL2. Aquatic habitat distribution
	☐ Map AL3. Aquatic habitat conditions
	☐ Form AL1. Summary of hypotheses
Water Quality	☐ Map WQ1. Water quality impairments
	☐ Form WQ1. Summary of water quality conditions
Historical Conditions	☐ Map HC1. Historical sites
	☐ Form HC1. Historical timeline
	☐ Form HC2. Trends in watershed resource conditions
Hydrology	☐ Map H1. Water control structures
	☐ Form H1. General watershed characteristics
	☐ Form H2. Summary of hydrologic issues by sub-basin
Channel	☐ Map C1. Channel segments
	☐ Map C2. Geomorphic channel types
	☐ Form C1. Historical channel changes
	☐ Form C2. Geomorphic channel type characteristics
Erosion	☐ Map E1. Land types
	☐ Form E1. Summary of erosion observations
	☐ Form E2. Summary of land type characteristics
Vegetation	☐ Map V1. Upland vegetation
	☐ Map V2. Riparian/wetland vegetation
	☐ Map V3. Land use practices that affect vegetation
	☐ Form V1. Vegetation category summary

Box 2. Synthesis questions

Community Resources

- What are the ecological needs of community resources relative to hydrology, erosion, stream conditions, vegetation, and water quality?

Aquatic Life

- What are the habitat requirements of aquatic life in the watershed?
- How is aquatic life affected by interactions among erosion, hydrology, riparian function, water quality, and stream channel processes?
- How is the distribution of aquatic species influenced by natural conditions?

Water Quality

- How have resources in the watershed been affected by pollutants?
- How do natural conditions in the watershed influence water quality in various waterbodies?
- How do natural conditions in the watershed influence the transport and fate of pollutants in the watershed?
- How have land use practices influenced water quality conditions in the watershed?

Historical Conditions

- When have land use/management changes altered watershed conditions?

Hydrology

- How do climate, geology, and topography influence surface and sub-surface water flow through the watershed?
- How has land use altered the flow of water through the watershed?
- How have alterations in the flow of water influenced conditions for resources?

Channel

- How do watershed climate, geology, and topography influence runoff, sediment transport, and aquatic habitat conditions?
- How do channel conditions influence physical and biological processes in the streams?

Erosion

- How do the climate, geology, and topography of the natural landscape influence sediment generation and transport in the watershed?
- How do land use activities change the frequency and magnitude of erosion at a watershed scale?
- How have alterations in the flow of water influenced conditions for resources?

Vegetation

- How have vegetation communities changed over time, and what has caused these changes?
- What riparian and wetland functions are important for protecting aquatic habitat, water quality, or other community resources?

The first day of Synthesis meetings is typically devoted to presentations of information gathered by the assessment team. Presentations should be tailored to the knowledge and experience of the participants in the Synthesis meeting (Box 3). After each presentation, additional time will typically be required to discuss the findings and consider information from other module analysts. The total time for each module presentation and discussion should be no more than one hour so that all the presentations can be completed in a day.

Box 3. Assessment team presentations

Each module analyst should present the following information:

- Module objectives and critical questions.
- A brief description of materials and methods.
- A summary of results using maps, figures, and tables.
- A discussion of the findings and the relationship to other modules.

Step 3. Identify connections between land use practices and resource impairment

After the first day of assessment team presentations, the Synthesis meetings should focus on outlining the linkages between modules and summarizing watershed issues. Depending on the complexity of watershed issues, the amount of available information, and the size of the watershed, this step may require from one to several days to complete.

Outlining potential connections among land use practices, watershed processes, and community resources can be approached from a number of angles. In a Level 1 assessment, starting with a resource is typically a good way to begin developing potential explanations or hypotheses for impairment (Box 4). Information from various modules can provide insight on the potential for delivery of hazardous inputs or the influence of natural conditions on the state of the resource. The Synthesis group should work together in developing various hypotheses and identifying the most promising hypotheses as watershed issues.

Hypotheses should be scrutinized based on the following:

- An evaluation of plausible alternatives.
- Existence of supporting scientific data.
- Different lines of supporting evidence.
- The ability of factors to amplify or attenuate an effect.

Box 4. Identifying connections between an impaired resource and land use practices, an example from the Penobscot River basin, Maine

Step 1. Identify Impaired Beneficial Resource
One of the critical issues in the Penobscot River basin, Maine, is a fish consumption advisory due to contamination with mercury, dioxin, and PCBs. Fish are an important cultural resource for the Penobscot Indian Nation, and angling is an important recreational activity for the entire watershed community.

Step 2. Identify Potential Sources of Impairment
Potential sources of these pollutants include discharge of wastewater from paper mills, contaminated sediments in the Penobscot River, aerosol deposition from industrial smokestacks, and naturally occurring mercury-bearing rocks.

Step 3. Identify Relevant Watershed Processes and Data Needs
Water chemistry data are important for identifying potential point source discharges. Stream sediment composition, pollutant load, and transport characteristics are important data to determine the significance of this source of pollutants. Geology information may also be crucial for identifying potential natural sources of mercury. Since fluctuating water levels allow mercury to be methylated and thus susceptible to uptake by biological organisms, information on changes in streamflow and dam operations may also be important.

Step 4. Identify Promising Hypotheses and Information Gaps
Point source discharges of pollutants from wastewater and smokestacks are the most likely sources of impairment. Little information exists on contaminated sediments and the potential for biological uptake, but this is potentially an important source. A review of geologic data revealed that rocks in the area contain minimal amounts of mercury.

Evaluating hypotheses will help to identify gaps in knowledge, increase confidence in cause-and-effect relationships, and prioritize future actions.

The Synthesis group may find that in some cases it is easier to develop hypotheses around a landscape sensitivity or land management practice. Landscape sensitivities might include a landform that is particularly susceptible to erosion or a vegetation community that is easily disturbed. Land management practices that are consistently causing problems can also be the focus of a hypothesis. For example, forest road construction within 100 feet of streams may consistently cause sedimentation problems, or stormwater discharge into shallow lakes may cause an increase in algae bloom size and duration.

Step 4. Summarize watershed issues

Watershed issues can be categorized in three general ways: 1) by community resource, 2) by hazardous input (e.g., pollutant), or 3) by land use practice (Box 5). Categorizing watershed issues is a subjective process, but it is important to provide detailed information on the issues in a form that the Scoping participants and the management team can understand and use to make decisions. The following details should be provided for each issue:

- The management activities potentially causing impairment.
- The location of hazardous inputs.
- The location of sensitive resources.
- The mechanism of impairment.
- Data and other evidence to support conclusions.

At this point, it will be helpful to review the issues identified during Scoping in light of the Watershed Assessment and the discussion of hypotheses. Based on this discussion, general watershed issues identified during Scoping may need modification to better reflect current knowledge or to highlight specific concerns. New watershed issues may also be identified.

Box 5. Organizing watershed issues, example from the Penobscot River basin, Maine

The Penobscot River basin has a number of beneficial resources impacted by point source discharge of pollutants such as PCBs, dioxin, and mercury (Box 4). The issue of mercury loading is sufficiently complex and different from the other pollutant issues to merit consideration on its own. While impairment of resources was the focus of initial discussions, the watershed issues in this case were more logically organized according to the hazardous inputs: 1) PCBs and dioxin, and 2) mercury.

Form S1 provides a template for summarizing important watershed issues (Box 6, Figure 1). Form S1 is one of the primary products of the Synthesis process and will be a key element of the last two WAM steps: Management Solutions and Adaptive Management. The following paragraphs describe each element of Form S1 in further detail.

Box 6. Information to include in Form S1. Summary of watershed issues

Watershed Issue:	Community Resource, Hazardous Input, or Land Use Practice
Location:	Sub-basin, Stream Segment, Waterbody, or Landform (reference maps and figures as necessary)
Situation Summary:	Input from Watershed, Time Frame, Watershed Process, Hazard Location, Management Activity, Delivery Conditions, Sensitive Resource Location, Channel and Resource Effects
Recommendations:	Level 2 Assessment, Management Changes, Restoration Plan, or Monitoring Plan
Justification:	Supporting Data, Criteria for Resource Sensitivity, Delivery Potential, Confidence in Assessment

Watershed Issue: The community resource, hazardous input, or land use practice that is the focus of the issue should be clearly identified.

Location: The area affected by the particular watershed issue should be referenced as specifically as possible. The location may be as large as the entire watershed or a sub-basin or as specific as one stream segment or landform. Reference appropriate maps to help people who are unfamiliar with the watershed or who did not participate in the assessment.

Figure 1. Sample Form S1. Summary of watershed issues

Watershed Issue: Soil Erosion

Location: Erosion Units 1 and 2 (Map E1) in the Bear Creek and Crazy Creek sub-basins.

Situation Summary:
Soil erosion is a problem in Erosion Units 1 and 2 due to disturbance of erodible soils from 1) road construction, 2) rerouting of water drainage from paved surfaces, 3) compaction of soil from grazing, and 4) natural erosional processes (weathering, soil creep, dry ravel, bank erosion). Sediment delivery to streams generally occurs within 75 feet of waterbodies. Most of the problems occur in low-gradient, moderately-incised streams in loess deposits (Channel Type 8). The accumulation of fine particles affects fish and aquatic plants by 1) reducing egg to fry survival for fish by cementing gravel and reducing the flow of oxygen, and 2) preventing the growth of snake reeds, which are an important tribal resource for basket-weaving and traditional medicine.

Recommendations:
1. Work with rural residential and forest landowners to develop options for reducing sediment delivery from gravel roads.
2. Work with the County Land Development and Engineering department to improve current and future water drainage structures and storm runoff detention.
3. Develop grazing management plan to reduce streambank trampling and to revegetate riparian corridors.
4. Conduct a Level 2 assessment to better quantify the sources of erosion.
5. Monitor the percentage of fine sediment before and after implementation of BMPs.

Justification:
Field observations, anecdotal information, and stream surveys provide evidence for the erosion problems in these two land types. Gant et al. (1999) and unpublished tribal and county reports provide more detailed examples of problems. While a high level of fine particles probably existed naturally in streams running through these loess deposits, land management practices have visibly increased their volume. A level of 30% fines or higher was considered a problem based on habitat requirements for fish. A high level of confidence exists in identifying the causes for erosion because of its broad documentation. A Level 2 assessment, however, would help to quantify each source of erosion and thus help in prioritizing and justifying management solutions.

Situation Summary: The situation summary describes the watershed problem in a simple and structured fashion (Box 7). The basic elements of the situation summary are provided in Box 6 and are illustrated in Box 8.

Box 7. Developing situation summaries

Development of situation summaries can be a time-consuming process that requires focused writing and editing. While these summaries rely on information from several different modules, it may be desirable to have one individual or group of individuals produce initial drafts of the situation summaries outside of the Synthesis meetings. Rather than spending the entire group's time describing each watershed issue in detail, the Synthesis meetings can then be more effectively used to critique and modify the draft situation summaries.

Box 8. Sample situation summary

Input from Watershed	Fine sediment
Time Frame	from past and potential future
Watershed Process	soil erosion in
Hazard Location	Erosion Units 1 and 2
Management Activity	due to 1) disturbance of erodible soils from road construction, 2) rerouting of water drainage from paved surfaces, 3) compaction of soil from cattle grazing, and 4) natural erosional processes (weathering, soil creep, dry ravel, bank erosion)
Delivery Conditions	within 75 feet of streams and wetlands
Channel Effects	has caused and/or could cause accumulation of fine particles
Sensitive Resource Location	within low-gradient, moderately-incised channel types in loess deposits (Channel Type 8)
Resource Effects	that can 1) reduce egg to fry survival for fish by cementing gravel and reducing the flow of oxygen and 2) prevent the growth of snake reeds, which are an important tribal resource for basket-weaving and traditional medicine.

Recommendations: The quality of data available for the Watershed Assessment, the assessment scale or level of detail, and the confidence in conclusions drawn from the assessment will all influence potential recommendations (Box 9). The intent of making recommendations is to provide guidance for future steps rather than to develop specific management solutions. Management solution development will occur in the next step of the WAM process.

Box 9. Confidence in recommendations

Lack of quality data or confidence in the assessment results should lead to further study in the form of a Level 2 assessment or longer-term monitoring. Strong evidence for cause-and-effect relationships is required to recommend management changes or restoration plans.

Justification: Providing evidence for conclusions from the Watershed Assessment is one of the most important exercises in the Synthesis process. Sources of data or other evidence should be referenced to support the situation summary. The standards or criteria used to rate landscape hazards, resource sensitivities, and delivery potentials should be clearly described. Finally, confidence in the assessment and conclusions should be discussed. A High/Moderate/Low rating can be used to assess confidence, but the summary should also provide explanations for each rating (Box 10).

Box 10. Confidence summaries

Rating confidence in the assessment and conclusions should be based on the following:

- The availability of information.
- The quality of information.
- The ability to analyze and interpret the data.
- The lack of alternative explanations.

Step 5. Produce Watershed Assessment report

The assessment team leader is typically responsible for producing an overall Watershed Assessment report. The format for this report is flexible, but the report should provide easily accessible information to community members. In most cases, a concise report will be more effective in communicating watershed issues than will a complex technical document with extensive data. Striking a balance between the need to communicate effectively with a potentially diverse audience and the need to provide scientific documentation to support conclusions is one of the greatest challenges in creating a useful Watershed Assessment report.

While each module analyst should have a short report on assessment results, the team leader must synthesize this information to provide a comprehensive picture of watershed conditions. This comprehensive picture can be effectively presented as the watershed story, a narrative that describes historical conditions and evaluates the effects of changes over time. The format of the Watershed Assessment report is flexible, but the report should describe important results and conclusions in a succinct manner (Box 11). The maps, tables, and forms produced in each module are designed to provide concise summaries of results as well as logic tracking for quality assurance and control.

Box 11. Example outline for a Watershed Assessment report

I. Introduction
- A. Purpose/objective of assessment
- B. List of sponsors and participants
- C. Watershed issues
- D. Regulatory or policy issues

II. Description of Watershed
- A. Location, size, ownership, and land uses
- B. Topography, geology, soils
- C. Climate
- D. Streams, sub-basins, waterbodies
- E. Vegetation
- F. Historical land uses and disturbances

III. Summary of Watershed Assessment
- A. Watershed story
- B. Summary of issues
- C. Recommendations
- D. Research and monitoring needs
- E. Confidence in assessment
- F. Quality assurance and control

IV. Technical Module Reports
- A. Community Resources
- B. Aquatic Life
- C. Water Quality
- D. Historical Conditions
- E. Hydrology
- F Channel
- G. Erosion
- H. Vegetation

Form S1. Summary of watershed issues

Watershed Issue:
Location:
Situation Summary:
Recommendations:
Justification: